Hysteresis performance of Y-type perfobond rib shear connectors

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ABSTRACT: The hysteresis performance of Y-type perfobond rib shear connectors has been investigated with various transverse rebars (D10, D13 and D16). Cyclic loading tests were conducted and energy dissipation and stiffness degradation characteristics were evaluated. Total amount of energy dissipation increases with the diameter of transverse rebars, and stiffness degradation ratio at early stage decreases with increasing diameter of transverse rebars. Y-type perfobond rib shear connectors can be adopted efficiently for seismic performance of composite structure to be improved.

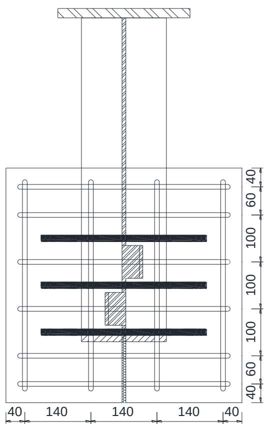
1. INTRODUCTION

Steel-concrete composite structures are widely adopted to achieve more efficient structure system. The shear connectors play important roles in composite effect and prevent separation between steel part and concrete part. Hysteresis performance of shear connectors under cyclic loads may affect the ultimate behavior of composite structure. Studies on the hysteresis performance of shear connectors were performed since the 1980s to investigate the decrease in stiffness, strength and ductility (Hawkins and Mitchell, 1984, Bursi and Gramola, 1999). Recently, the Y-type perfobond rib shear connectors were developed to improve the performance of shear connectors (Kim et al., 2013), and the Y-type perfobond rib shear connectors have shown superior shear capacity and ductility. Kim et al. (2017) have carried out the cyclic loading tests with Y-type perfobond rib shear connectors and compared with stud shear connectors. The excellent hysteresis performance of Y-type perfobond rib shear connectors has been demonstrated. In Y-type perfobond rib shear connections, the transverse rebars play important roles to improve the ductility of Y-type perfobond rib shear connectors (Kim et al., 2017). The studies on the development of mathematical hysteresis model with BWBN model (Baber and Noori, 1985) for Y-type perfobond rib shear connectors are ongoing. In this study, monotonic and cyclic loading tests were conducted with various diameters of transverse rebar and the hysteresis performances have been evaluated.

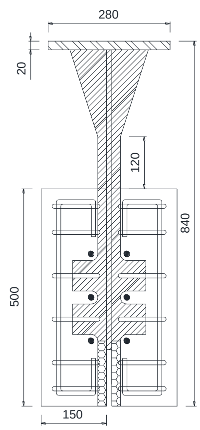
2. CYCLIC LOADING TEST

In test specimens shown in Figure 1, the Y-type perfobond ribs have the following dimensions: 8 mm thickness, 50 mm height, and 30 mm hole diameter, respectively. 3 different transverse rebars were used: 10 mm, 13 mm, and 16 mm and specimens were labelled as D10-C/M, D13-

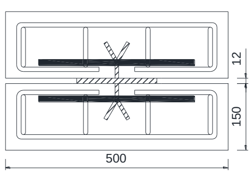
C/M, D16-C/M (C: Cyclic loading test / M: Monotonic loading test). The compressive strength of concrete was 30 MPa.



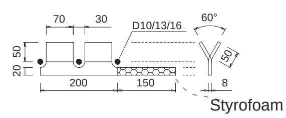
(a) Front view



(b) Side view



(c) Plan view



(d) Y-type perfobond rib shear connectors

Figure 1: Dimensions of specimen (unit: mm)

Figure 2 shows the cyclic load history for cyclic loading test. Each displacement amplitude has repeated 3 times in same manner from 0.2 mm to 40 mm.

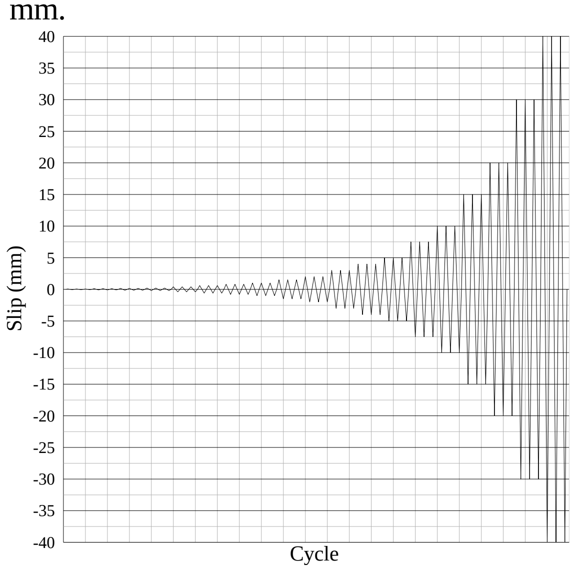
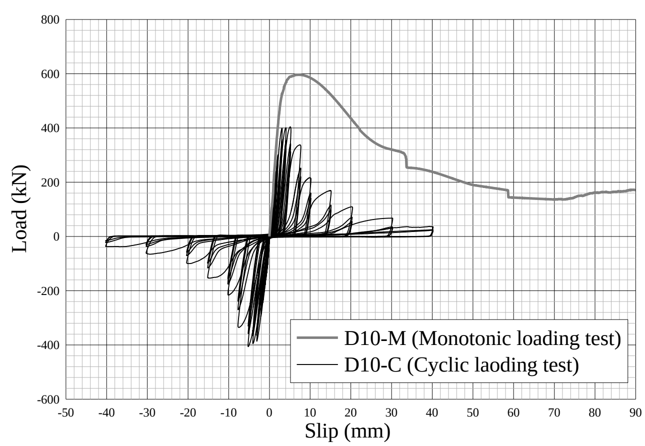


Figure 2: Cyclic load condition for cyclic loading test.

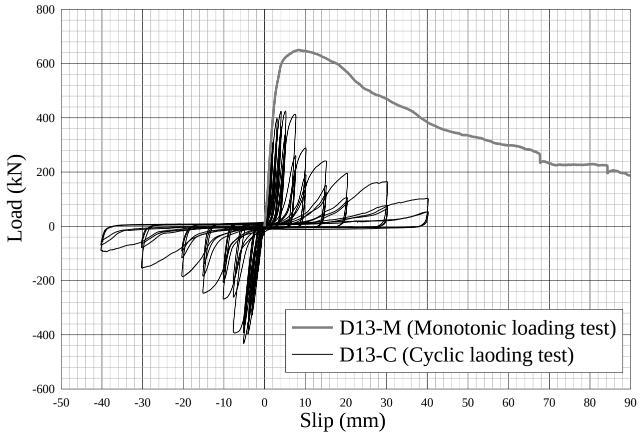
3. TEST RESULTS

The test results with D10-M/C, D13-M/C, and D16-M/C are summarized in Figure 3. The shear strengths of D10-M, D13-M, and D16-M specimens are 596.0 kN, 649.8 kN, and 683.6 kN, respectively. The maximum loads that the specimens have experienced in cyclic loading tests are 0.68(D10-C), 0.65(D13-C), and 0.66(D16-C) compared to the shear strengths obtained in monotonic loading tests.

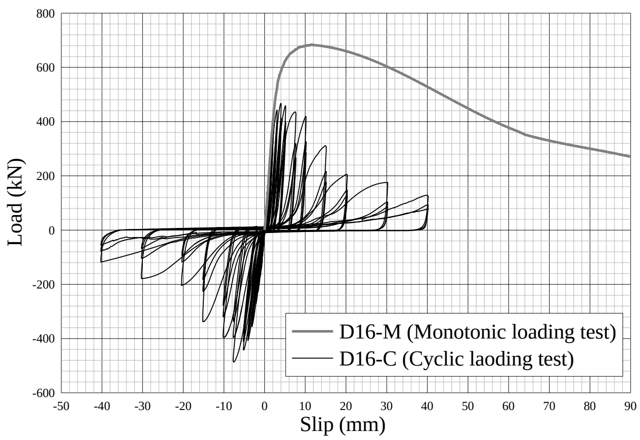
Figure 4 shows the accumulative energy dissipation amount with increasing slip from 0.2 mm to 40 mm. Figure 5 contains the energy dissipated ratio in each slip amplitude. The total amount of energy dissipated through the whole cyclic loadings for the D10-C specimen is 22,497 kN·mm. The total energies dissipated in D13-C and D16-C have increased with increasing rebar size by 58%(D13-D) and 95%(D16-C) with respect to the D10-C. The increasing rate of total energy dissipated in D10-C becomes slow after slip of 15 mm. However, the increasing rates in the specimens with larger rebars are found to keep the similar trend upto 40 mm. In the Figure 5, it is found that the peak energy dissipation ratio in each step is achieved at the slip of 15 mm in D10-C. However, D13-C shows the peak at 30 mm slip and D16-C at 40 mm slip.



(a) Specimens with D10 transverse rebars



(b) Specimens with D13 transverse rebars



(c) Specimens with D16 transverse rebars

Figure 3: Load–slip curves obtained from the cyclic and monotonic loading test.

Figure 6 presents the ratio of residual stiffness to the initial stiffness at 1.5mm slip cycles (25th). The initial stiffnesses of 3 different specimens are evaluated to be 159 kN/mm(D10-C), 167 kN/mm(D13-C), and 210 kN/mm(D16-C), respectively. The numbers of cycles for the residual stiffness to be reduced up to 80 % of initial stiffness in D10-C, D13-C and D16-C are 29th, 31th and 33th, respectively. However, 41 cycles are required for the residual stiffness to be decreased up to 20 % in all the specimens.

Figure 7 shows the BWBN models established for the D10-C, D13-C and D16-C. The BWBN models are compared with experimental results on the basis of the normalized force and slip.

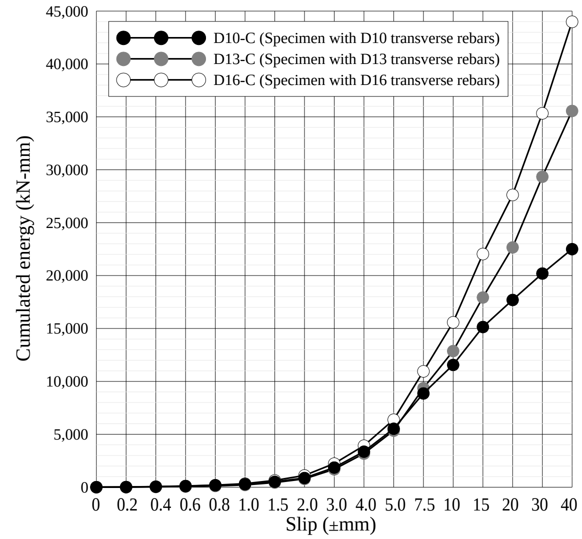


Figure 4: Accumulative energy dissipated.

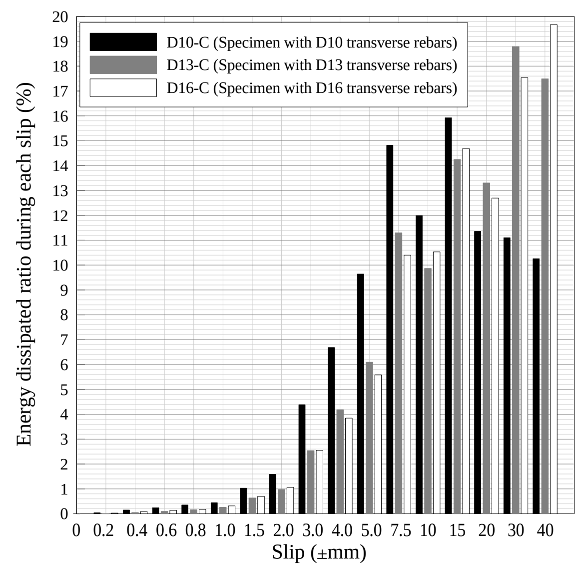


Figure 5: Energy dissipated ratio.

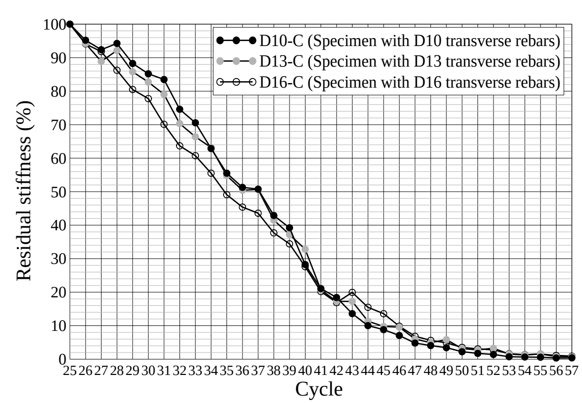
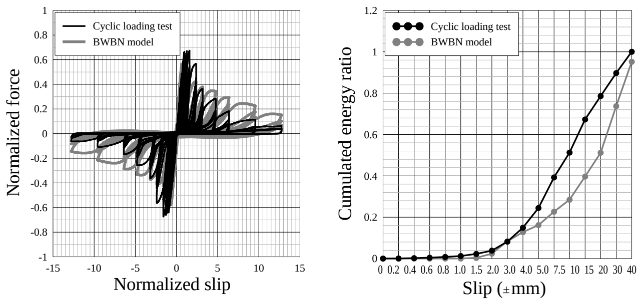
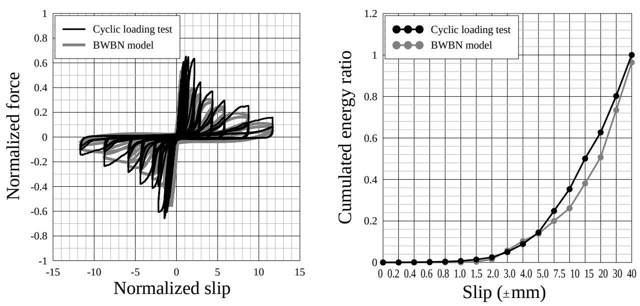


Figure 6: Stiffness degradation of Y-type perfobond rib shear connectors

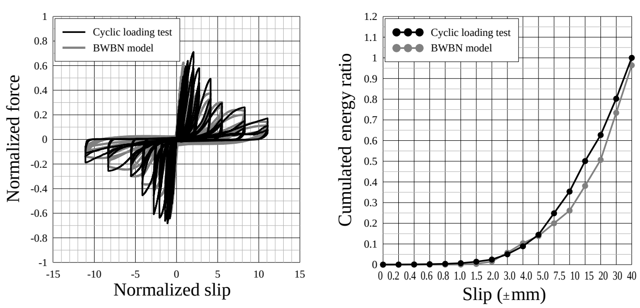
In the process of BWBN model set-up the major target goal was that the total energy dissipated in the BWBN model became to be same as the energy dissipated in the experiment.



(a) D10-C



(b) D13-C



(c) D16-C

Figure 7: Hysteresis behavior of BWBN model.

4. CONCLUSIONS

The hysteresis performance of Y-type perfobond rib shear connectors have been evaluated through cyclic loading tests. It has been found that the transverse rebars installed through the holes of Y-type perfobond ribs play important roles in the energy dissipating capacity under the hysteretic loading as well as the shear resistance capacity under the monotonic loading. It is very important to select a proper rebar size, which is compatible to the strength of Y-type rib. If the rebar adopted in Y-type perfobond rib shear connectors is too strong compared to the Y-type rib, the steel ribs may get damaged in the early stage of the loading and the stiffness as well as the energy dissipating capacity may be decreased significantly. BWBN model is found to be adopted efficiently for the nonlinear analytical model under hysteretic loadings.

5. ACKNOWLEDGMENTS

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